analyzing the amplitudes, durations and the transit velocities of propagated mitral flow velocities.

1093-52 Color Doppler Energy Assessment of Aortic Regurgitant Fraction: An In Vitro Study

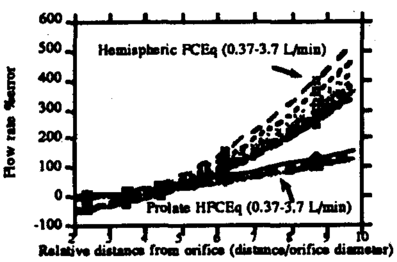
E.T. Lee, C.L. Reid, J.M. Gardin, E.G. Cape. *Children's Hospital, University of Pittsburgh, PA, USA , University of California Irvine Medical Center, Orange, CA, USA*

Color Doppler energy (CDE) is an imaging modality which provides a tomographic matrix of integrated intensity over the entire imaging plane. The CDE intensity represents the number of moving scatterers passing through each sample volume independent of insonation angle. We have previously shown in a steady flow system that CDE correlated with forward and reverse flows, and is capable of calculating volumetric flow ratios and regurgitant fraction (RF). For aortic regurgitation, a short-axis CDE image should indicate the number of scatterers moving through the imaging plane over the time of frame acquisition. This study addressed the *hypothesis* that RF can be accurately measured using quantitative measures of CDE during regurgitation and forward flow. *Methods:* Using an in vitro pulsatile flow loop and two orifice sizes (8 mm and 12 mm), various degrees of regurgitation (regurgitant fractions from 15%–68%; 15 conditions) were studied and actual flows were measured using an electromagnetic flow probe. Cross-sectional images were obtained using CDE (Acuson 128XP-10) and recorded, with instrument settings held constant. By off-line computer analysis, regurgitant fractions were calculated by summing cross-sectional mean intensities (energies) for reverse flow and dividing by the sum of cross-sectional mean intensities during forward flow. *Results:* CDE RFs showed excellent correlations with fractions measured from the flow probe ($RF_{CDE} = 0.973RF_{PROBE} + 0.68$; $r = 0.96$; SEE = 5.16). *Conclusions:* In in vitro studies, CDE provides an accurate measure of regurgitant fraction over a wide range of aortic valvular insufficiencies. Short-axis views are easily obtained in patients and should allow CDE measurements of regurgitant fraction to be applied clinically.

1093-53 Analysis of a Modified Flow Convergence Equation for Calculation of Aortic Regurgitant Flow Rate: A Numerical Study

C.G. DeGroff, R. Shandas, L. Valdes-Cruz. *The Children's Hospital, Denver, CO, USA*

The flow convergence (FC) isovelocity contours in aortic regurgitation (AR) are constrained by the aortic walls thereby resembling prolate hemispheres rather than simple hemispheric surfaces. Direct comparisons between FC methods using these two geometric models for calculating AR flows have not been conducted. *Methods:* We used 3-D finite volume axisymmetric numerical models to simulate 10 steady flows (0.37–3.7 L/min) through an AR orifice (aortic diameter 2.65 cm, & AR diameter 0.57 cm). AR flows were calculated using the standard FC equation, flow = surface area* isovelocity. The transverse and axial radii of FC isovelocity contours were measured to calculate prolate hemisphere surface areas at set distances from the orifice. AR flows were also estimated using the hemisphere FC method and compared to the prolate hemisphere FC results. *Results:* Figure shows % error in AR flows by both methods. AR flows calculated using the prolate hemisphere FC method are accurate close to the orifice (~2 orifice diameters) with some overestimation further from the orifice. The hemisphere FC method underestimates AR flow close to the orifice but results in flow overestimation which increases exponentially at greater distances from the orifice.



Conclusions: The prolate hemisphere FC method is more robust than the simple hemisphere FC method ford estimating AR flow due to the constraining effects of the vessel walls. The prolate hemisphere FC method can be easily automated and should allow for accurate clinical quantitation of AR flow.

1093-54 Impact of Jet Orientation and Pulmonary Venous Flow Direction on Color Doppler Flow Mapping of Mitral Regurgitation: an In Vitro Study With Optical Dye Correlations

G. Griever, T. Shiota, A. Passafini, D.J. Sahn, F. Manrique. *Oregon Hlth Sci Univ, Portland, OR*

In this study, the effect of pulmonary venous (PV) flow direction on color flow Doppler (CFD) of mitral regurgitant jets (MR) was evaluated in an in vitro setting and observations correlated with optical dye visualization in a left atrial (LA) model built with a PV inflow (1.0 cm in diameter) and MR orifice 0.15 cm^2 in the same plane. With LA pressure at 10 mmHg, we studied condition A: with PV flow directed away from the MR orifice, and condition B: with PV flow directed towards the MR orifice. For CFD, we used a Toshiba scanner with a 3.75 MHz transducer at 4 KHz or 8 KHz PRF. PV flow was driven by a steady flow pump and MR flow was pulsatile. When imaged in the plane of PV inflow, maximal MR jet areas for A imaged at 4 KHz PRF were significantly larger than for the wall jets in B (8.4 ± 0.7 (SD) vs 7.0 ± 0.9 cm^2, $p < 0.05$), but were not different when imaged at 8 KHz (A = 6.3 ± 0.2 vs. B = 6.4 ± 0.4 cm^2). For matched conditions, optical dye areas of the MR jet (8.9 ± 0.1 cm^2) agreed better with color Doppler images at 4 KHz than 8 KHz. In contrast, in a plane perpendicular to the PV MR interaction, MR jet areas imaged by optical visualization revealed *smaller* maximal jet areas in condition A than in B (10 ± 1.7 vs 13 ± 1.0 cm^2, $p < 0.05$). The dye studies revealed jet deflection and adjacent wall effect (Coanda) as the mechanism for the PV MR interaction. Complex swirling interactions and secondary circulation of pulmonary venous flows were observed as producing the alteration of mitral regurgitant jets.

1093-55 Can "Left Ventricular Ejection Time" Still Be Used as a Marker of Critical Aortic Stenosis?

H. Karpuz, X. Jeanrenaud, N. Aebischer, A. Delabays, N. Debbas, J.J. Goy, L. Kappenberger. *Division of Cardiology, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland*

In aortic stenosis (AS), measurement of jet velocity by Doppler-echocardiograph provides accurate determination of pressure gradients and aortic valve area (AVA) by the continuity equation. However, recording of jet velocity may not be possible in technically difficult patients (pts) and serious underestimation of AS can occur. The purpose of this study was to evaluate prospectively a simpler Doppler parameter to identify pts with critical AS (AVA ≤ 0.75 cm^2 or ≤ 0.45 cm^2/m^2) determined by the Gorlin formula at cardiac catheterisation (CC). This parameter, the "Ejection Time (ET) difference (ΔET)", is defined as Doppler-measured ET minus predicted ET. The predicted ET was derived from Doppler-determined stroke volume (SV) using a regression equation (described by Harley as: 0.002 SV + 0.106). ET and SV were determined from pulsed Doppler recordings at the aortic annulus. Sixty-one pts (13 women, mean age 60 ± 12 years) suspected AS, were included. ΔET was calculated in all the pts by the same physician without knowledge of CC results.

	AVA ≤ 0.45 cm^2/m^2	AVA > 0.45 cm^2/m^2
ΔET ≥ 0.045 sec.	33	3
ΔET < 0.045 sec.	3	22
	Sensitivity 92%	Specificity 88%

Conclusion: The Ejection Time difference is a simple parameter to identify critical aortic stenosis especially in pts in whom accurate determination of aortic valve area is difficult with conventional methods. A ΔET ≥ 0.045 sec. allows detection of critical aortic stenosis (≥ 0.45 cm^2/m^2) with good sensitivity and specificity.

1093-56 Is Effective Orifice Area of Mitral Stenosis Variable with Flow? A Color M-Mode Flow Convergence Analysis

S.F. Yiu, M.E. Sarano, B. Cormier, A. Vahanian, J.B. Seward, A.J. Tajik. *Mayo Clinic, Rochester, USA, Hospital Tenon, Paris, France*

Objectives: In mitral stenosis, the effects of changes of flow in the effective orifice area of mitral valve are uncertain. Analysis of the proximal flow convergence (PISA) allows evaluation of transvalvular hemodynamics. These issues have been tested in stress conditions while the measurements are difficult and may not be reliable and has not been tested with changes of flow occurring during the normal cardiac cycle.

Methods: In 20 patients (16 females, 61 ± 13 years) with mitral stenosis, mitral valve area (MVA) was measured by planimetry (2D), PISA and pressure half-time (PHT) method. Using Color M-mode with aliasing velocity of 22 ± 5 cm/s, analysis of timed transvalvular hemodynamics was performed at 71

± 18 and 177 ± 57 msec after mitral valve opening.

Results: Mitral score was 7 ± 2 with mean gradient of 6.0 ± 2.7 mmHg. The valve areas by Color M-mode (1.47 ± 0.36 cm^2) was not significantly different from 2D, PHT and PISA methods (1.49 ± 0.42, 1.47 ± 0.30 and 1.37 ± 0.38 cm^2 respectively). MVA as determined by Color M-mode did not differ from either 2D ($p = 0.57$), PHT ($p = 0.99$) or PISA ($p = 0.14$). The timed calculations showed marked changes in flow without changes in valve area as noted below.

	Early Diastole	Mid Diastole	p value
Flow (ml/sec)	247 ± 62	189 ± 53	< 0.001
Velocities (cm/sec)	173 ± 39	129 ± 30	< 0.001
MVA (cm^2)	1.47 ± 0.36	1.51 ± 0.40	0.27

Color M-mode MVA correlated well with the 3 reference methods in early and mid diastole. 2D ($r = 0.80$ $p < 0.01$ vs. $r = 0.69$ $p < 0.01$ respectively), PHT ($r = 0.65$ $p < 0.01$ vs. $r = 0.48$ $p < 0.05$ respectively) and PISA ($r = 0.69$ $p < 0.01$ vs. $r = 0.53$ $p < 0.05$ respectively).

Conclusions: In patients with mitral stenosis color M-mode analysis of flow convergence (1) shows good correlation to Doppler and 2D derived mitral valve area. (2) Allows analysis of transvalvular hemodynamics under different flow conditions. (3) The results suggest that with variations of mitral flow, there is no significant changes of mitral valve areas observed.

1093-57 Left Ventricular Volume by 2-D Echocardiography, Better Preoperative Assessment for Left Ventricular Function in Patients With Mitral and Aortic Regurgitation

H. Almansour, L. Hatle. *King Faisal Specialist Hospital & Research Centre, Riyadh, Saudi Arabia*

In significant mitral and aortic regurgitation and left ventricular (LV) dilatation accurate assessment of LV systolic function is necessary for optimal timing of surgery. The indications for surgery based on LV volumes and ejection fraction (EF) by angiography have been replaced by M-mode dimensions and fractional shortening (FS) by echocardiography. Changes in LV shape may result in underestimation of LV size and LV impairment when measured by M-mode Echocardiography. We studied 54 patients with mitral and 57 patients with aortic regurgitation with dilated LV, and compared the dimensions and FS obtained by M-mode measurements with volumes and EF determined by 2-D Echocardiography using the modified Simpson's rule. A significant number of patients who did not fulfill the criteria for surgical decision by M-mode dimensions and FS had volumes exceeding accepted criteria and reduced EF. Of the 54 patients with mitral regurgitation, 30 patients had EF < 55% and 18 only had FS < 31%. Of the 57 patients with aortic regurgitation 35 had EF < 50% while FS was < 29% in only 15 patients. Thus in 22% of the patients with mitral regurgitation and in 35% of the patients with aortic regurgitation the LV impairment indicated by volume data would have been missed if relying on the reported M-mode data.

Conclusion: Due to changes in shape and in longitudinal shortening, quantitative 2-D echocardiographical assessment of LV volumes and EF may provide a better assessment for timing of surgery in aortic and mitral regurgitation.

1094 Advances in Echocardiography

Wednesday, March 19, 1997, 3:00 p.m.–5:00 p.m.
Anaheim Convention Center, Hall E
Presentation Hour: 4:00 p.m.–5:00 p.m.

1094-25 A Multicenter Trial Comparing FS069 and ALBUNEX® for Left Ventricular Endocardial Border Delineation

J. Cohen, D. Bruns, E. Hausner, J. Gottdiener, C. Dick, M. Picard, L. Crouse, C. Pollick for the FS069 Multi-Center Study Group. *Molecular Biosystems, Inc., San Diego, CA, USA*

FS069 is a new ultrasound contrast agent comprised of perfluoropane filled albumin-shell microspheres. Its safety and efficacy for improving the assessment of left ventricular (LV) function were compared with those of ALBUNEX® (ALB) in 203 patients (160 males-79%; 43 females-21%). 74 of these patients formed a subgroup with impaired LV and/or pulmonary function, factors known to limit ALB efficacy. 0.08 and 0.22 mL/kg ALB and 0.2, 0.5, 3.0 and 5.0 mL of FS069 were given IV. LV endocardial border delineation (EBD) and LV chamber opacification (LVO) were assessed by blinded review with results of 0.22 mL/kg ALB and 3.0 mL FS069 reported. Adverse events were noted in 8.9% of patients following ALB and 6.6% following FS069. End diastolic endocardium increased in length by 3.45 cm with ALB vs. 7.44 cm with FS069, $p < 0.0001$ while systolic endocardial length increased by 1.56 cm with ALB vs 4.81 cm with FS069, $p < 0.0001$. EBD improved by one or more segments (of 6 total from apical 4 chamber view) in 75% of all patients with ALB vs. 93% with FS069, $p < 0.0001$. LVO of ≥ 2+ (on a scale of 0 to 3+) occurred in 56% of all patients with ALB vs. 93% with FS069, $p < 0.0001$. In the impaired function subgroup, LVO of ≥ 2+ was 36% with ALB vs 91% with FS069, $p < 0.0001$. These results demonstrate the safety of FS069 with superior efficacy to ALB for all patients regardless of the presence of factors which inhibit contrast efficacy.

1094-26 Prospective Reproducibility of an Autonomous Boundary Detection (ABD) Method in Healthy Young Adults

M.S. Cunningham, E.A. Geiser, D.C. Wilson, D. Wang, C.S. Brown, D.J. Milburn, D.A. Conetta. *University of Florida, Gainesville, Fl, USA*

Purpose: Bedside evaluation of the repeatability of LV chamber size and function estimates from an ABD algorithm for epicardial and endocardial border detection.

Method: Parasternal short axis images were obtained from 20 healthy volunteers. Six cycles were obtained in polar digital format from each subject with a one hour lapse between the first and last three cycles. The end-diastolic (ED) and end-systolic (ES) epi- and endocardial borders were estimated by the ABD system on the cycle felt to have best border definition at each point in time. Five independent observers, 3 trained and 2 in-training, traced the epi- and endocardial borders at ED and ES. Chamber areas at ED and ES, fractional area change (FAC), and muscle area (MA) were calculated. Observer and ABD standard deviations (SD) were calculated for the differences in variables over time in the 18/20 volunteers having adequate tracking of epi- and endocardial borders.

Results:

	Trained			In-training 4 5		
Observer SD's	1	2	3	4	5	ABD
Endo ED (cm^2)	2.89	3.24	3.18	2.34	4.78	2.72
Endo ES (cm^2)	1.80	2.66	1.50	1.86	2.00	2.15
MA (cm^2)	1.96	3.28	2.43	2.78	6.43	2.27
FAC (%)	4.4	7.6	6.6	7.3	14.0	4.9

Conclusion: This autonomous algorithm for definition of epi- and endocardium offers reproducibility of measurement similar to trained echocardiographers and superior to those in-training.

1094-27 Enhancement of Left Ventricular Endocardial Border Delineation with Sonicated Human Albumin (Infoson™) Infusion during Dobutamine Stress Echocardiography: Useful or Useless?

B. Benhalima, A. Cohen, C. Chauvel, M. Khirredine, K. Mezzi, B. Muan, I. Desert, B. Blanchard, M. Lombardi. *Saint Antoine University Hospital, Paris, France, Pisa, Italy*

In order to evaluate the enhancement of left ventricular (LV) endocardial border delineation during dobutamine stress echocardiography (DSE), sonicated Human Albumin (Infoson™: Nycomed imaging Norway) was infused at baseline and peak in 30 patients, 5 women and 25 men, mean age 61 ± 11.

Apical two and four chamber views were divided into six segments each. We determined LV Ejection Fraction (EF) using the area-length method and the percentage of segments which had an optimal enhancement. The mean dose of dobutamine and Infoson™ infusion was 36 ± 6 μg/kg/mm and 10.5 ± 1 ml/kg respectively.

More than 80% of the injections resulted in intermediate or full LV opacification. No significant side effects related to Infoson™ infusion were observed. No significant difference was observed with regard to LVEF before and after Infuson™ infusion at baseline (60 ± 11 versus 65 ± 10%, respectively) and peak (59 ± 13 versus 61 ± 10%). Visual analog scales scores grading the ability to detect the LV endocardial borders were not significantly different before and after Infoson™ injection. Image quality was inchanged by Infoson™ injection in the majority of patients. Finally, the probability of concordance between the 2 observers in wall motion scoring was not influenced by the Infoson™ injection at rest and peak (0.70 versus 0.69 and 0.63 versus 0.61) respectively.

Conclusion: Although Infoson™ is a safe contrast agent when given intravenously, this did not improve LV endocardial border delineation nor did it facilitate wall motion analysis in this study.